

A NEW SET OF MEASUREMENTS OF ^{26}Al IN LUNAR CORE 79002/1. R. Grismore¹, R. A. Llewellyn², A. G. Amoranto¹, and M. D. Brown², ¹Physics Department, California Polytechnic State University, San Luis Obispo, CA 93407; ²Department of Physics, University of Central Florida, Orlando, Florida 32816-2385.

The authors submitted a proposal in 1994 to the Lunar Sample Curator at NASA/JSC for the loan of several samples ranging over the length of a lunar core, the particular core to be chosen by the Curator. The purpose for the measurement of ^{26}Al in the core samples was to study surface anomalies, such as the effects of gardening and/or possible accretion of particles from the solar wind or other sources. Such anomalies were to be detected and assessed by comparing the measured values of ^{26}Al concentration with cosmic-ray production predictions from the Reedy-Arnold model [1].

The proposal of 1994 was granted, and the authors were loaned four samples ranging over the dissection length of lunar core 79002/1. The double drive tube of this core was driven into the regolith approximately 70 m south-east and downslope from the rim of the 90-m-diameter Van Serg Crater and approximately 15 m northeast of a subdued ~60-m-diameter crater at station 9 of the Apollo 17 mission [2]. The bulk densities after extrusion of the materials from the two drive tubes differ slightly; tube 79002, which ranged from the surface to 17.4 cm, had bulk density 1.76 g/cm^3 , and tube 79001, ranging from 17.4 to 46.7 cm, had bulk density 1.90 g/cm^3 [3]. The core material had a dark-light boundary (dark above, light below) at a depth ranging from 8.5 to 11 cm, and the soil from above the boundary is very mature, much more so than that from below the boundary [2,3]. The depth ranges and masses of the samples which the authors received are listed in Table 1 below. Each sample was epoxy-impregnated, and represented a quarter of a right circular cylinder of core material with a radius of approximately 2 cm and length between 2.1 and 2.9 cm. Each epoxy encapsulation block was a rectangular parallelepiped with dimensions ~1.5 cm x 1.5 cm x (core material length). Blank sample epoxy blocks were also supplied by the Lunar Sample Curator for background counting purposes.

The samples from 79002/1 were measured for ^{26}Al using a multidimensional gamma-ray spectrometer (MGRS) which was originally built by the first author at Indiana State University in 1972 [4]. In 1987 this spectrometer was moved to California Polytechnic State University, San Luis Obispo, and set up there, modified only by replacing the original liquid-scintillation, Compton-suppression ring counter by a Bicorn BC-400 plastic ring counter 0.46 m in diameter by 0.305 m high. The two main detectors, 0.15-m diameter by 0.10-m high NaI(Tl) crystals, face the sample volume at a distance of 0.025 m apart, yielding a counting geometry of 83% of 4- π at the center of the volume. The electronics which amplify and process the coincidence-anticoincidence signals have been found to be extremely stable, with drift being less than 1% over counting runs lasting as long as two weeks. The counting data are sorted into a 126-channel by 126-channel analysis plane. Compton suppression, analysis in the plane, and lead shielding have made it possible to achieve an average background counting rate of only ~1.3

counts/24^h/channel over the whole counting plane from 0.2 to 2.5 MeV. This, in turn, makes it possible to measure samples for ^{26}Al down to a level of about 0.3 dpm/sample. In order to check the accuracy of the method used to assay for ^{26}Al , comparison was made with assays made by the BNWL Group on two meteorite samples using the same type of multidimensional gamma-ray spectrometer. The present authors obtained values of $33 \pm 5 \text{ dpm/kg}$ and $44 \pm 6 \text{ dpm/kg}$ for their fragments from the Murchison and Allende meteorites, respectively. The BNWL Group have reported values of $36 \pm 2 \text{ dpm/kg}$ (Murchison) and a range of values from 51 ± 2 to $64 \pm 3 \text{ dpm/kg}$ (Allende) for the ^{26}Al concentrations in their separate fragments from the two meteorites [5].

The results of the ^{26}Al measurements made by the present authors are shown in Table 1 below. The radioassays were made by comparing numbers of counts in full-area-at-half-maximum between the spectra from the sample and corresponding spectra from a 310 dpm calibrated ^{26}Al standard source which was obtained from Isotope Product Laboratories of Burbank, California. The standard source approximated the samples in size and shape. In the radioassay process, the 0.511-MeV x 0.511-MeV and two symmetric 0.511-MeV x 2.320-MeV peaks in the spectra were used. A check was always made to ensure that the assay from the 0.511-MeV x 0.511-MeV peak agreed with the assays from the other two peaks so as to exclude the possibility of the presence of any significant amounts of positron emitters other than ^{26}Al in the sample. It should be noted that the ^{26}Al calibration source was

restandardized in our laboratory using a single 0.076-m diameter by 0.076-m high NaI(Tl) scintillation detector and data given by Neiler and Bell [6]. Owing to the method used in the restandardizing process, the possibility exists of a 5% systematic error in the radioassays shown in Table 1.

After completing the above measurements, the authors learned that 13 samples of bulk fines from 79002/1 had been previously measured for ^{26}Al and other radionuclides by Nishiizumi, *et al.*, using AMS methods [3]. The results from Table 1 and those from Reference [3] have been plotted in

TABLE 1. MGRS measurements of ^{26}Al radioactivities in samples from the 79002/1 lunar cores.

Sample Number	Depth Range (g/cm ²)	Mass* (grams)	^{26}Al Activity (dpm/kg)
79002,6007	0-4.4	6.293	43 ± 5
79002,6013	25.7-30.3	6.545	35 ± 8
79001,6009	54.4-60.1	7.293	52 ± 8
79001,6015	81.9-86.3	5.584	44 ± 10

*Mass values supplied by NASA/JSC.

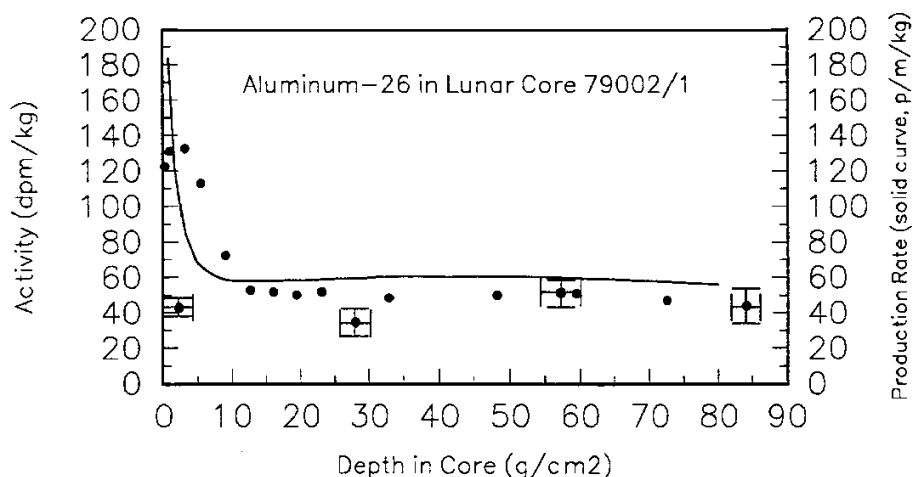
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Fig 1. Production and decay rates of ²⁶Al in lunar core 79002/1. Solid curve is predicted production rate from Reedy-Arnold model reproduced from Ref. [3]. Solid circles are Nishiizumi AMS measurements from same reference (diameter of circles represents maximum vertical error bars shown for those measurements). Points with error bars drawn represent the measurements by the present authors. Horizontal error bars represent the depth ranges of the samples, and vertical error bars represent the uncertainties of the measurements.

Figure 1 below. As can be seen from the figure, the measurements of Table 1 agree very well with the Nishiizumi results for our two deeper samples. Both sets of measurements indicate that the decay rate is following the production rate curve very well, but at a level which indicates only 80-83% saturation, suggesting that the deeper material of the core has only been this near to the surface for slightly less than 2 My. The really strange result to be seen from this figure is that the surface sample measurement from the present work shows an ²⁶Al concentration which is only about one-third of those found by Nishiizumi and predicted by the modeling calculations. Also, the second deepest sample of the present work shows a concentration which is about two standard deviations below the corresponding Nishiizumi results. In the effort to check the anomalous result obtained for our surface sample (79002,6007), that sample was subjected to five different counting runs for a total counting time of 630 hours, and the inescapable result was that this sample does have an unusually small concentration of ²⁶Al. In light of the fact that our surface sample must have come from a position in the 79002 core tube only 2 cm or less from the upper Nishiizumi samples, this suggests that the epoxy-impregnated samples from core tube 79002 must have suf-

fered some sort of mishap during collection and processing; such occurrences have been suggested as possible by Reedy and Marti [7]. Owing to the anomalous nature of the results on our two upper samples, it has not been possible to draw any conclusions regarding gardening or surface accumulation of ²⁶Al from this work on the 79002/1 cores. To attempt to resolve the question as to what is wrong with the 79002 epoxy-impregnated samples, the authors have requested and been granted the loan of 5 grams of bulk fines from the uppermost portion of 79002, and this material will be measured for ²⁶Al concentration, and the results reported, as soon as possible.

References: [1] Reedy R. C. and Arnold J. R. (1972) *JGR*, 77, 537. [2] Morris R. V. et al. (1989) *Proc. LPSC*, 19, 269. [3] Nishiizumi K. (1994) *LPSC*, XXV, 1003. [4] Grismore R. et al. (1975) *Rev. Sci. Instrum.*, 46, 243. [5] Evans J. C. et al. (1982) *JGR*, 87, 5577. [6] Neiler J. H. and Bell P. R. (1965) in *Alpha-, Beta- and Gamma-Ray Spectroscopy*, ed. by K. Siegbahn (North-Holland, Amsterdam), 1, p. 290-291. [7] Reedy R. C. and Marti K. (1991) in *The Sun in Time*, ed. by C. P. Sonett, M. S. Giampapa, and M. S. Matthews (The University of Arizona, Tucson), p. 284.